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DIFFERENCES IN LEARNING OUTCOMES BETWEEN A NEW AND A TRADITIONAL CHEMISTRY COURSE.

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ASSESSED WERE COGNITIVE DIFFERENCES BETWEEN HIGH SCHOOL STUDENTS WHO WERE TAUGHT CONVENTIONAL CHEMISTRY AND THOSE WHO WERE TAUGHT CHEMICAL BOND APPROACH (CBA). FOUR COGNITIVE PREFERENCES WERE CHOSEN FOR STUDY--(1) RECALL OF FACTS AND TERMS, (2) PRACTICAL APPLICATIONS, (3) CRITICAL QUESTIONING OF INFORMATION, AND (4) IDENTIFICATION OF A FUNDAMENTAL PRINCIPLE. THESE PREFERENCES WERE VIEWED IN RELATION TO--(1) ACHIEVEMENT, AND (2) ABILITY. A COGNITIVE PREFERENCE TEST INSTRUMENT FOR HIGH SCHOOL CHEMISTRY WAS DEVELOPED AND USED. IT CONSISTED OF 100 ITEMS TO WHICH THE STUDENT COULD RESPOND BY ANY ONE OF FOUR STATEMENT OPTIONS, EACH OF WHICH WAS CORRECT, BUT REPRESENTED DIFFERENT COGNITIVE PREFERENCES. THE EXPERIMENTAL GROUP INCLUDED 24 TEACHERS AND 433 STUDENTS CHOSEN FROM SCHOOLS WHICH WERE USING THE CBA CHEMISTRY PROGRAM. THE CONTROL GROUP, USING A TRADITIONAL CHEMISTRY PROGRAM, UTILIZED 30 TEACHERS AND 622 STUDENTS. IT WAS FOUND THAT STATISTICALLY SIGNIFICANT DIFFERENCES WERE OBTAINED BETWEEN THE TWO GROUPS. THE CBA GROUP SHOWED A PREFERENCE FOR (1) CRITICAL QUESTIONING, AND (2) FUNDAMENTAL PRINCIPLE OPTIONS ON THE TEST. THE CONTROL GROUP SHOWED PREFERENCES FOR RECALL OF FACTS OPTIONS, WHILE BOTH GROUPS SHOWED THE SAME PREFERENCE FOR APPLICATION OPTIONS. THE POSSIBILITIES OF DIFFERENCES BEING DUE TO (1) ABILITY, AND (2) ACHIEVEMENT WERE TESTED AND REJECTED. (DH)

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Ronald L. Marks

October 1, 1966

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I. Introduction

One of the many new curricula developed for high school science courses recently is the Chemical Bond Approach (CBA) Project. Supported by private and National Science Foundation funds, the Chemical Bond Approach Project Committee was founded to develop the new course. Until the development of the CBA course, much of the chemistry being taught was based on memorization of specific chemical facts or terms and on practical application of these facts. It was felt by the CBA Committee that for application of chemical knowledge to take place basic understandings of chemical theory had to be acquired first. Thus, the CBA course of study revealed the importance of theory and experiment. To emphasize the theoretical approach the CBA Committee chose, as a central theme for the course, the relationship between chemical bonds and the interactions of species in chemical systems.

The development of the new course of study was one problem, but to evaluate the student's fulfillment of the goals of the course was quite another. One study which was completed and which attempted to evaluate the new CBA course used traditional achievement testing procedures.(3) To the extent that the CBA and traditional courses are alike in goals, the study was successful. But by the nature of the two courses, the goals are considerably different. The problem was to find a measure which could reliably differentiate some of the aims and objectives of CBA chemistry as they were compared to traditional chemistry.

During the 1961-1962 school year, Robert W. Heath, of the Educational Testing Service, developed an instrument which he called a Cognitive Preference Examination. The examination was used to show how at least one of the goals of the new Physical Science Study Committee (PSSC) physics differed from that of traditional physics.

> The problem of assessing student progress toward the distinctive goals of the new curricula is not a simple one. The body of psychometric skills now available has largely grown out of traditional educational practices. It seems necessary to approach the problem from a frame of reference which is different in its conception of achievement and therefore different in method of measurement.
>
> The interest is not in whether the student can identify correct or incorrect information but rather in what is he likely to do with information intellectually. If a goal of instruction is to change the student's intellectual style within some academic subject, a test of such

"achievement" must permit time to demonstrate differing styles. The test items should allow the student to exhibit some preference in cognition. (4)

Statement of the Problem: If, in fact, the CBA curriculum does have a goal of instruction which would change the intellectual style of the student (i.e., the student's mode of problem solving or inquiry), a student oriented in CBA chemistry should exhibit cognitive preferences which are significantly different from those preferred by students enrolled in a traditional chemistry course. The purpose of this study is to study the cognitive preferences of CBA and traditional chemistry students in an attempt to identify certain goal differences between the type of curricula. In the form of a question: is there a significant difference in cognitive preferences as exhibited by students taking the CBA chemistry course and students in the traditional course?

Four cognitive preferences were chosen for the study: (1) memory or recall of specific facts or terms, (2) practical application, (3) critical questioning of information, and (4) identification of a fundamental principle. Some other, or perhaps different, cognitive preferences are: (1) laboratory technique, (2) descriptive chemistry, (3) theoretical interpretation, (4) correlation of data with theory, etc. The former were chosen because of the close relation "memory" and "practical application" have to the older curriculum. "Critical questioning of chemical information" and "identification of a fundamental principle" should appeal to the CBA students.

Sub-problems:

1. The cognitive preferences as exhibited by the students will be related to achievement in the two types of curricula. In the form of a question: is there a significant difference in the four cognitive preferences chosen for the study as exhibited by students taking the CBA chemistry course and the students in the traditional course when related to achievement?

2. The cognitive preferences as exhibited by students will be related to their ability. In the form of a question: is there a significant difference in the four cognitive preferences chosen for the study as exhibited by students taking CBA chemistry course and the students in the traditional course when related to ability?

Hypotheses:

With a sample of classes enrolled in CBA chemistry and a sample of classes enrolled in traditionally taught chemistry,

the following hypotheses were tested:

1. Students in the CBA chemistry course and the students in the control groups show no statistically significant difference in their preferences for fundamental principle and critical questioning as measured by the Cognitive Preference Test.

2. Students in the CBA chemistry course and students in the control groups show no statistically significant difference in their preferences for memory of facts and practical application as measured by the Cognitive Preference Test.

The hypotheses for the sub-problems are as follows:

1. Students in the CBA chemistry course and students in the control groups show no statistically significant difference in their preferences for fundamental principle and critical questioning, as measured by the Cognitive Preference Test, when these preferences are related to achievement test scores (Cooperative High School Test and CBA Final Examination).

2. Students in the CBA chemistry course and students in the control groups show no statistically significant differences in their preferences for memory of facts and for practical application, as measured by the Cognitive Preference Test, when these preferences are related to achievement test scores (Cooperative High School Test and CBA Final Examination).

3. Any statistical difference in cognitive preferences is related to ability (SCAT).

The above hypotheses will be accepted as significant at the 0.05 level and highly significant at the 0.01 level of confidence.

II. Method

The investigator developed an instrument to measure the cognitive preferences of the students in the CBA and control groups. The instrument (Cognitive Preference Test: High School Chemistry) consists of 100 items, and gives the appearance of a four-option, multiple choice test. (See Appendix A). The introduction, or stem, provides the chemical information. Four "answers" or preferences follow the item. Each of the four preferences is correct. The student was informed that each of the options was correct, and that he was to select the choice he preferred most in connection with the introductory information.

Each of the items was designed so that the four options would designate a different form of cognitive preference in chemistry. The four preferences were stated above. The results, obtained from the students who took the Cognitive Preference Test, were scored as four separate subtests of 25 items each. The subtests corresponded to the four cognitive preferences.

An item analysis was computed from the Cognitive Preference Test. It was determined that each of the 100 items was a functional part of the test as a whole. Also, the reliability of the instrument was calculated and it was considered reliable for research purposes. (Greater methodological detail can be found in Appendix B).

A list of all known CBA chemistry teachers was catagorized on a two-variable stratification table. The two stratification variables were (a) sex of the teacher and (b) size of community (over or under 100,000 population). A random sample of these teachers was selected and invited to participate in the study. The teachers that accepted the invitation were catagorized on the same two stratification variables used for the CBA population. A chi-square value of 0.31 indicated that the CBA group was a representative sample from the population.

The non-CBA schools were selected. Invitations were issued to schools in proportion to the CBA population stratification. The distribution of the control sample was tested against the CBA sample by means of the chi-square test. No statistically significant difference was found.

In addition to the Cognitive Preference Test, with its four subtests, the following tests were used in the testing program: (a) A.C.S.-N.S.T.A. Cooperative Examination: High School Chemistry, Form 1961, a traditional achievement test, (b) The Chemical Bond Approach Project Final Examination, Part I, an achievement test for the new curriculum, and (c) The

School and College Ability Test, Parts I and IV, Form 1A.

The means and standard deviations of all tests, for both groups, were computed from the pre-test and post-test data. From these data, "t" tests were computed to determine if there was a significant difference between CBA and control group means for the four cognitive preferences. The possibility that the differences in cognitive preferences could be accounted for by differences in ability was tested.

Analysis of variance and intercorrelations of the mean scores of the seven variables (SCAT, CBA Final, A.C.S. Cooperative, Cognitive Preference Subtests) for both CBA and control groups were determined. This was in an attempt to investigate the sub-problem hypothesis that the cognitive preferences were related to achievement in the two types of curricula.

III. Results

The mean and standard deviation of all tests for the pre-test and post-test programs were computed for the CBA group and the control group. The statistics presented in Table I are based upon cluster samples of 24 teachers of CBA chemistry who made up the experimental group (433 students) and 30 teachers of traditional chemistry who made up the control group (622 students) for the post-test data. For example, the mean score for SCAT in Table I for the CBA group is 40.56. This value is the arithmetic average of 24 CBA cluster means on the SCAT test. Below that statistic the value of 5.29 represents the standard deviation of the 24 CBA cluster means on the SCAT.

Table I is a compilation of the data needed to test the major hypotheses to this study. The data necessary to test the hypotheses to the subproblems is not shown in this report because of the limitation on space and for the sake of clarity of presentation. However, in the next section, "Discussion," necessary references will be made to the analysis of variance data needed to test the hypotheses to the sub-problems.

TABLE I

COMPARISON OF MEANS ON ALL POST-TESTS

(d.f.= 52)

TEST	STATISTICS	CBA GROUP (N=24)	CONTROL GROUP (N=30)	t	SIGNIFICANCE LEVEL *
SCAT	Mean	40.56	37.58	1.97	0.06
	Standard Deviation	5.29	5.82		
A.C.S. Co p.	Mean	42.87	44.05	0.31	n.s.
	Standard Deviation	15.04	13.05		
CBA Final	Mean	12.65	9.33	3.61	0.01
	Standard Deviation	3.69	3.05		
Cognitive: Memory	Mean	7.61	8.99	3.14	0.01
	Standard Deviation	1.53	1.69		
Cognitive: Critical Quest.	Mean	7.03	6.25	2.68	0.01
	Standard Deviation	1.15	1.03		
Cognitive: Pract. App.	Mean	4.53	4.39	0.45	n.s.
	Standard Deviation	1.35	0.94		
Cognitive: Fund. Prin.	Mean	7.09	6.60	2.01	0.05
	Standard Deviation	0.88	0.91		

* Values not reaching the 0.05 level are recorded as not significant (n.s.) unless otherwise indicated.

IV. Discussion

The first major hypothesis was stated so that an attempt was made to determine if students in the CBA chemistry course and students in the control groups showed any statistically significant difference in their preferences for fundamental principle and critical questioning as measured by the Cognitive Preference Test. The results of the analysis of the data for the post-tests are shown in Table I.

The computed t-value for the difference between means of the CBA and control groups on the critical questioning and fundamental principle subtests were 2.68 and 2.01, respectively. With 52 degrees of freedom, (24-1) + (30-1), the tabled t-value is 2.01 at the 0.05 level. Therefore, the null hypothesis that there is no statistically significant difference between the CBA and control groups in their preference for critical questioning and fundamental principle options to the test items can be rejected.

The means for the CBA group and the control group on the critical questioning subtest are 7.03 and 6.25, respectively. The analysis would indicate that the differences between these means is highly significant and that CBA students did have a stronger preference for the critical questioning option on the Cognitive Preference Test. Similarly, the higher mean for the CBA group on the fundamental principle subtest would indicate a stronger preference by that group for the fundamental principle option than the control group.

The second major hypothesis related to an attempt to determine if students in the CBA group and students in the control group showed any statistically significant difference in their preferences for memory of facts and practical application as measured by the Cognitive Preference Test.

It is shown in Table I that a t-value of 3.14 was obtained for the difference between means for the memory subtest, and was highly significant beyond the one per cent level. For the differences between means on the practical application subtest, a t-value of 0.45 was obtained, which was not significant. The null hypothesis that the two methods of instruction produce no statistically significant difference in student preference for memory of facts was rejected. However, it could not be rejected for the practical application subtests.

The results shown in Table I indicated that the students in the control group, with a mean of 8.99, showed a stronger preference for the recall type option on the Cognitive Preference Test than did the CBA group, as is indicated by their mean score of 7.61. Further examination of Table VIII indicated

that the CBA and control groups had nearly identical preference (a mean difference of 0.14) for the practical application option to the test items.

Additional information in Table I indicates that there was no statistically significant difference between the CBA and control groups on the A.C.S. Cooperative Examination. This suggested that the method of instruction did not significantly affect the student's facility on this conventional achievement test. Further, the table indicated that the two groups showed a statistically significant difference in their ability as measured by the School and College Ability Test, Form 1A, Parts I and IV. It was noted that a significant difference had appeared on this same test in the pre-test data.

Also, Table I indicates that a highly significant difference existed between the means of the CBA and control groups on the CBA Final Examination. This difference showed an advantage for the CBA group which exhibited superior performance on the test designed for its own method of instruction.

Analyses of variance were performed on the data to determine if the ability of the two groups could account for their differences in cognitive preferences. The results indicated that the cognitive preferences of these students could not be related to their ability as measured by SCAT. The hypothesis which was the third sub-problem was rejected.

When achievement test scores were related to the cognitive preferences of students by means of analysis of variance, it was found that neither the A.C.S. Cooperative Examination nor the CBA Final Examination were criteria from which to forecast the cognitive preferences of these students. Thus, the hypotheses that the cognitive preferences as expressed by students could be related to achievement were rejected.

V. Conclusions, Implications and Recommendations

The mean scores for the CBA group and the control group on the fundamental principle subtest were 7.09 and 6.60 respectively. While this difference is statistically significant at the 0.05 level of confidence, it was felt by the investigator that a difference of approximately one-half an item on a 25-item test had little educational significance. That is, the obtained difference was not large enough to have curriculum revision implications.

Means of 7.03 and 6.25 for the critical questioning subtest were obtained for the CBA group and control group respectively. It can be inferred that this difference has possible educational significance. For example, school administrators may wish to accept the CBA course because the student engages in inquiry rather than the memorization of facts. One may also infer that one of the major objectives of the CBA curriculum is being realized. The CBA course of study encourages the student to interpret and analyze newly presented data from previously learned material.

Statistical analyses revealed a highly significant difference between the CBA group and the control group in their preference for the memory option in the Cognitive Preference Test items. This indicated that the control group had more of a preference for the memory or recall of information option than did the CBA group. It can be assumed that the traditional approach to teaching high school chemistry has as one of its goals of instruction the presentation of many facts and terms for the student to memorize. The CBA course has less emphasis on memorization.

The practical application subtest data were very interesting in light of present day discussions in chemistry education. The CBA course does not stress to any appreciable extent the practical application of chemical systems; yet, the CBA group and the control group had virtually equal preference for that option in the test items. The interesting educational inference that can be drawn from these means is not so much their lack of a statistically significant difference, but their numerical magnitude. A low mean for the CBA group on the practical application subtest could be assumed. However, if the traditional course has as much emphasis on practical application as it is purported to have, the students, at least the ones in this study, were not preferring it to the other goals of instruction.

Additional information of interest obtained from this study was that the CBA group and the control group showed no statistically significant difference on the A.C.S. Cooperative

Examination. The educationally interesting observation that can be inferred from these data is the fact that the CBA group did as well on the traditional achievement test as did the group taught in the traditional manner. The content of the A.C.S. Cooperative Examination is such that very little of it could be directly taught in the CBA course of study. However, it appeared that the CBA students were able to accept related material and work with it in light of what they had learned in the CBA course. On the other hand, the traditional students did not do nearly as well on the CBA Final Examination which stresses conceptualization as did the group of CBA students.

It is apparent from the data presented above that the CBA course of study is achieving at least one of its goals of instruction. The cognitive style of the students seem tied more to conceptual learning rather than to a verbal structure.

In light of the findings in this study and the conclusions drawn from them, research in the following areas may be desirable:

1. A study should be undertaken to determine if a two-option, 100-item cognitive preference test measure the intellectual style of students in an experimental and control group with any greater predictability than was prepared in this study with the four-option, 100-item test. The two options chosen for this kind of study should be memory of facts and critical questioning.

2. A study similar to this one should be undertaken except that different cognitive preferences in the options to the test-items should be written.

3. A study should be undertaken to determine if the laboratory program in high school chemistry has any influence on the cognitive preferences of students.

4. A study similar to this one should be conducted but should compare cognitive preferences of students enrolled in Biological Science Curriculum Study biology with those enrolled in more traditional courses.

5. A study should be undertaken to determine how much descriptive chemistry, in particular practical application to chemical systems, should be included in a high school chemistry program.

6. A replication of this study should be undertaken with the addition of a Hawthorne group to the CBA and control group.

VI. Summary

This investigation compared the cognitive preferences of students enrolled in Chemical Bond Approach Project (CBA) high school chemistry classes with the cognitive preferences of students enrolled in traditional high school chemistry classes. The comparison was made in an attempt to identify certain goal differences between the types of curricula.

The four cognitive preferences chosen for comparison in this study were: (a) memory or recall of specific facts, (b) practical application, (c) critical questioning of information, and (d) identification of a fundamental principle.

Also investigated was the possibility that the cognitive preferences, as expressed by the students, could be related to achievement in the two types of curricula. The possibility that the students' cognitive preferences were related to their ability was also investigated.

The investigator developed an instrument (Cognitive Preference Test: High School Chemistry) to measure the cognitive preferences of the students in the CBA and control groups. The instrument consisted of 100 items, and gave the appearance of a four-option, multiple choice test. The introduction, or stem, provided the chemical information. The four "answers" which followed the stem designated a different form of cognitive preference. The student was informed that each of the options was correct, and that he was to select the option he preferred most in connection with the introductory information.

An item analysis was computed from the Cognitive Preference Test. It was determined that each of the 100 items was a functional part of the test as a whole. Also, the reliability of the instrument was calculated and it was considered reliable for research purposes.

Based on the sex of the teacher and size of the community, a random sample of twenty-six schools throughout the United States offering the CBA course was representative of the CBA population. A random sample of thirty-two schools throughout the United States offering a traditional chemistry course constituted the control group. A chi-square test indicated the control sample was representative of the CBA sample when tested on the same stratification variables.

In addition to the Cognitive Preference Test, the following tests were used in the testing program: (a) A.C.S.-N.S.T.A. Cooperative Examination: High School Chemistry, Form 1961, (b) The Chemical Bond Approach Project Final Examination, Part I, and (c) The School and College Ability Test, Parts I and IV, Form 1A.

Analysis of the pre-test data indicated that there was no statistically significant difference between the CBA and control groups in their preferences for the memory of facts, practical application, fundamental principles or critical questioning options to the test items.

The post-test analysis showed that a statistically significant difference did exist between the CBA and control groups in three of the four cognitive preferences. The CBA group exhibited a stronger preference for the critical questioning and fundamental principle options to the Cognitive Preference Test items. The control group showed a stronger preference for the memory of facts option. Analysis of the data indicated that both groups had virtually the same preference for the practical application option. The mean score for each of the groups was significantly lower for the practical application option when compared to the mean scores for the other three cognitive preferences.

An analysis of variance, factorial design, was computed to investigate the possibility that the cognitive preferences, as expressed by the students, could be related to achievement in the two curricula. One such relation which existed was that the CBA classes which had lower scores on the CBA Final Examination had a stronger preference for the practical application option than did the corresponding group of traditional classes.

The possibility that the students' cognitive preferences were related to their ability was tested and discounted.

VII. References

1. Garrett, Henry E. Statistics in Psychology and Education New York: Longmans, Green and Co., 1961. p. 366

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3. Heath, Robert W. "A Study of Achievement in High School Chemistry," Report to the Chemical Bond Approach Project, Educational Testing Service. Princeton, New Jersey. October, 1962.

4. Heath, Robert W. "Curriculum, Cognition, and Educational Measurement," Educational and Psychological Measurement, SSIV, No. 2. Summer, 1964. pp. 240-241.

VIII. Appendix A.

The Cognitive Preference Test: High School Chemistry.

IX. Appendix B

Methodological Detail

The Cognitive Preference Test: High School Chemistry is a 100-item test. (A copy of the test is found in the Appendix to this study). The general appearance of an item in the test is that of a four option, multiple choice question. Each item has a stem which presents some information or data of a chemical nature. Each of the four options is factually correct and related to the stem of the item. The directions for the administration of the test read, in part, as follows:

> In this test you are to indicate which one of four choices you prefer. Each test item begins with an introductory statement or diagram. This information is followed by four lettered choices. Each of these choices is correct.
>
> Read the introductory statement and all four choices carefully. Select the choice you prefer most in connection with the introductory information. Then blacken the corresponding space on your answer sheet. Remember, all the information given is factually correct. You should choose the answer that has most appeal or is most satisfying to you because of the chemistry course you had.
>
> You may find that more than one choice for each test item appeals to you. However, select the one choice for each item. Be sure to answer every question, even though the decision may be difficult to make.

The four options for each of the items were written so that the reader could express his preference for a given style of thinking. To the limitation of the number of options, the reader could express a cognitive preference which is most satisfying to him.

One of the options is related to the stem as a preference for memory or recall of specific facts or terms. A second choice was designed to indicate a practical application of the information given in the stem. Another option designates the reader's preference for challenging or critically analyzing the information in the stem. A fourth option has an appeal for a fundamental principle which explains, at least in part, the information given in the stem.

Item 87 from the test reads as follows:

Vegetable oils become fats by combining the oil with hydrogen.

(a) Crisco is the result of such a process.
(b) The process is called hydrogenation.
(c) Hydrogen can be added to certain unsaturated covalent bonds.
(d) Addition of hydrogen to vegetable oils liberates heat. Saturated fats are therefore more stable than unsaturated fats.

A student may receive the most satisfaction by answering the above item with (a). Such an answer may result as a score toward his "practical application" total score. A choice of (b) may count toward his "memory" total score. If the student prefers (c) as his answer, a point may be added to his "fundamental principle" score. (d) would be the correct answer for the "critical questioning" part of the test.

Method of Evaluating the Results Obtained from the Cognitive Preference Test. Since each of the answers is correct, the Cognitive Preference Test would have an undesirable interdependent quality built into it. That is, if one answer were chosen by a student, three other correct answers would be eliminated from the total test score. For example, suppose a student were to have a preference of option (a) for an item while a second student were to have a preference for option (b) for the same item. The result would be that the item would be evaluated one way for the one student while a different evaluation would be obtained for the second student. The resulting ipsative measurement for each student would be distributed about the mean of that student, not about the sample mean. "Individual differences in ipsative measurements have little meaning because there is not a single scale for all individuals." (2) Therefore, the 100 items were divided into four subtests corresponding to the four cognitive preferences. In this way, it was possible to evaluate, or grade, for the total score of just one of the cognitive preferences. A maximum score possible for any one of the four subtest was 25.

The result of the division of the test into subtests was that four, 25-item tests were considered in the scoring of the test. So that each subtest would be evenly distributed throughout the test with respect to the other three subtests, the following assignments were made: The Memory Test was composed of test items 1, 5, 9, 13 ... 97. Critical Questioning was scored for items 2, 6, 10, 14 ... 98. The items designated for Practical Application were 3, 7, 11, 15 ... 99. Items 4, 8, 12, 16 ... 100 scored for the Fundamental Principle subtest.

Validity of the Test Items in the Cognitive Preference Test. The validity of the items in the Cognitive Preference Test was determined by a jury of seven chemists. The jury members read

each of the test items to determine (1) if the item was factually correct in subject matter, (2) if the cognitive preferences were truly related to the stem of the item, and (3) if the general content covered in the test was representative of a first course in chemistry.

As a result of the comments and suggestions received from the chemists, several items were revised or rewritten. It was the consensus of the jury that the final form of the test was valid with respect to the above points.

An Analysis of Each Item in the Cognitive Preference Test. An item analysis was performed to determine if each of the items in the Cognitive Preference Test was a functional part of the entire test. The procedure used was to identify the upper and lower twenty-seven per cent of the total score distribution for each subtest. The proportion of examinees in the group representing the highest twenty-seven per cent and lowest twenty-seven per cent provided the data to enter Flanagen's table of normalized biserial coefficients as published in Garrett (1) or the abac in Guilford. (2)

The obtained index estimated how well the item correlated with the total test score. In general, the higher the validity index the better the correlation. A validity index of 0.20 or higher is usually considered satisfactory although with more than 1000 examinees in this study, a validity index as low as 0.08 would be significant at the 0.05 level of confidence. The item analysis indicated that 97 of the items on the Cognitive Preference Test had a validity index of 0.20 or higher. The other three items had an index of between 0.13 and 0.20. Each item was considered to be a functional part of the test.

Reliability coefficients of each of the subtests of the Cognitive Preference Test. Coefficients of reliability for each of the subtests of the Cognitive Preference Test were determined to furnish some estimate of the reproducibility of test scores. The results are shown in Table II, page 39. The procedure used to determine the coefficients was first to determine the Pearson product-moment coefficient of reliability between the odd and even items of each subtest. The Spearman-Brown formula was then used to obtain an estimate of reliability of the whole test. It was concluded that the four subtests were reliable and could be used for research purposes.